CENTRIFUGAL PUMPS WITH INTERNAL COOLING

[0001] Centrifugal pumps are generally discussed herein with particular discussion on centrifugal pumps comprising internal motor casing cooling and optional low profile.

CROSS-REFERENCE TO RELATED APPLICATION

[0002] Benefit is claimed to provisional application No. 60/400,667, filed on August 5, 2002, the contents of which are expressly incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0003] Centrifugal pumps for pumping fluids are known in the art. In general, centrifugal pumps comprise a driver, which is typically a motor or a steam turbine, and a driven equipment, which is typically the hydraulic pressure generating portion of the pump comprising one or more impellers. To pump fluids, rotational force generated by the driver is transferred to the pump, which then imparts kinetic energy to the inlet fluids through its one or more impellers. As the fluids enter the volute section of the pump after the one or more impellers, the kinetic energy is converted into pressure.

[0004] Submersible pumps for operating in a sump or a pit are also known in the art. Generally speaking, submersible pumps comprise a casing that houses both the driver and the driven components. The driver component is isolated from the fluids to be pump by static seals, such as O-rings or gaskets, and dynamic seals, such as a mechanical seal or a dynamic packing material. The driven component is typically an impeller coupled either directly to the driver shaft or by way of a coupling.

[0005] Although prior art submersible pumps have been available for a number of years, the prior art pumps still have several shortcomings. For example, the prior art motors used to drive the pumps often operate at elevated temperatures due to the insulation provided by the casings to isolate the motors from the fluids. In addition, the inlet and outlet lines are generally relegated to one portion of a pump section, which limits the operability of the pump and creates a larger than necessary pump profile.

[0006] Accordingly, there is a need for a pump that is economical and one that does not suffer from the same prior art shortcomings. In addition, there is a need for a pump that can operate in both a submersible service and an open-air service.

SUMMARY OF THE INVENTION

[0007] The present invention specifically addresses and alleviates the above-mentioned deficiencies associated with the prior art assemblies. More particularly, the present invention may be implemented by providing a centrifugal pump comprising a casing having two casing sections defining a casing cavity; an electrical motor comprising a motor casing having two ends and a side positioned therebetween mounted inside the casing cavity having a motor shaft protruding from one of the ends, a seal mounted on the motor shaft for deterring fluids from leaking into an interior space of the motor casing, an impeller mounted on an end of the motor shaft adjacent the seal; and a flow channel formed between an inlet nozzle and an outlet nozzle inside the casing cavity adapted to permit fluids drawn from the inlet nozzle to flow over a least a portion of the side of the electrical motor to cool the electrical motor before exiting the outlet nozzle.

[0008] The present invention may also be practiced by a method for pumping fluids using a centrifugal pump comprising connecting an inlet line and an outlet line to a pump casing, the pump casing comprising an inlet nozzle and an outlet nozzle, turning on an electrical motor comprising a motor casing having two ends, a side positioned therebetween, and a motor shaft extending through one of the ends, passing fluids through the inlet nozzle and out the outlet nozzle by generating a suction at the inlet nozzle with an impeller mounted on an end of the motor shaft; deterring seepage of fluids into an interior cavity of the electrical motor by sealing the motor shaft and one of the ends with a dynamic packing or a mechanical seal; cooling the electrical motor by providing a flow passage between the inlet nozzle and the outlet nozzle and allowing at least a portion of the fluids to flow pass at least a portion of the side of the motor casing before exiting the outlet nozzle.

[0009] In other aspects of the present invention, a centrifugal pump is provided comprising an electrical motor having a motor shaft and an impeller mounted on the motor shaft positioned inside an interior cavity of a casing having a parting line, the casing comprising an inlet nozzle on one side of the parting line and an outlet nozzle on an opposite side of the parting

line, a flow channel extends between the inlet nozzle and the outlet nozzle with at least a portion of the flow channel defined by the casing and an outside section of the electrical motor; and at least one support leg located on an exterior surface of the casing for supporting the centrifugal pump.

[0010] Still yet another aspect of the present invention comprises a centrifugal pump comprising a casing having two casing sections removeably attached to one another at a parting line, the two casing sections defining an interior cavity having an electrical motor comprising a motor housing having a motor shaft extending from an end of the motor housing and having an impeller mounted on the motor shaft, wherein the casing comprises a geometrical shape having a large mid-section and two tapered ends with an inlet nozzle on one of the tapered ends and a outlet nozzle on the other tapered end.

[0011] Other aspects and variations of the apparatus and method summarized above for the centrifugal pump are also contemplated and will be more fully understood when considered with respect to the following disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] These and other features, aspects and advantages of the present invention will be more fully understood when considered with respect to the following detailed description, appended claims and accompanying drawings, wherein:

[0013] FIG. 1 is a semi-schematic perspective view of an exemplary centrifugal pump provided in accordance with aspects of the present invention;

[0014] FIG. 2 is a semi-schematic cross-sectional side view of the centrifugal pump of FIG. 1;

[0015] FIG. 3 is a semi-schematic cross-sectional side view of a pump casing section provided in accordance with aspects of the present invention;

[0016] FIG. 4 is a semi-schematic end view of the pump casing section of FIG. 3 taken along line F4-F4;

[0017] FIG. 5 is a semi-schematic cross-sectional side view of another pump casing section provided in accordance with aspects of the present invention;

[0018] FIG. 6 is a semi-schematic end view of the pump casing of FIG. 5 taken along line F6-F6;

[0019] FIG. 7 is a semi-schematic cross-sectional side view of a motor electrical cover provided in accordance with aspects of the present invention;

[0020] FIG. 8 is a semi-schematic end view of the motor electrical cover of FIG. 7 taken along line F8-F8; and

[0021] FIG. 9 is a semi-schematic cross-sectional side view of an exemplary impeller provided in accordance with aspects of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0022] The detailed description set forth below in connection with the appended drawings is intended as a description of the presently preferred centrifugal pump embodiments provided in accordance with aspects of the present invention and is not intended to represent the only forms in which the present invention may be constructed or utilized. The description sets forth the features and the steps for constructing and using the centrifugal pumps of the present invention in connection with the illustrated embodiments. It is to be understood, however, that the same or equivalent functions and structures may be accomplished by different embodiments that are also intended to be encompassed within the spirit and scope of the invention. Also, as denoted elsewhere herein, like element numbers are intended to indicate like or similar elements or features.

[0023] A semi-schematic perspective view of an exemplary centrifugal pump assembly provided in accordance with aspects of the present is shown in FIG. 1, which is generally designated 10. The centrifugal pump assembly 10 comprises a housing 12, which has a housing inlet nozzle 14 and a housing outlet nozzle 16 with each having an opening 18, 20. Each nozzle also comprises exterior or interior threads for piping termination. Alternatively, grooves for cam-lock fittings, flanges, and other conventional nozzle terminations may be used for piping inlet and outlet lines.

[0024] In one exemplary embodiment, the housing 12 defines a lengthwise dimension having a lengthwise axis, to which the inlet nozzle 14 and outlet nozzle 16 may be generally aligned to. In this configuration, the pump is said to have an in-line configuration. Alternatively, the inlet and outlet nozzles 14, 16 may be opposed but on different planes or different lengthwise axes. Still alternatively, the openings 18, 20 may be positioned at an angle to one another on either the same end or on opposite ends of the pump 10.

[0025] In one exemplary embodiment, the housing 12 comprises mating housing parts, which may include two or more parts. In the embodiment shown, the housing 12 comprises a first, front, or inlet housing casing 22 removeably and matingly attached to a second, back, or discharge housing casing 24 along a parting line 26. Although the shape can vary, in one exemplary embodiment, the housing 12 comprises the shape of a football, which has a large mid-section and tapers into two dome sections at opposite ends of the mid-section. To provide the pump with a slim profile, the nozzles 14, 16 may be placed at the ends or the tips of the tapered dome sections. Conventional attachment means 28 such as fasteners, clamps, straps, screws and nuts, screws and integrally formed threaded receptacles, etc., may be used to mechanically couple the discharge housing casing 24 to the inlet housing casing 22. The number of attachment means 28 can vary but should be enough to provide sufficient compressive distribution along the parting line 26 to ensure a leak tight parting line. As further discussed below, a soft compressive body such as a gasket or an O-ring may be used with the parting line 26 to further enhance sealing at the parting line.

[0026] One or more housing support posts 30 may be incorporated to provide mounting support or positioning support for the pump assembly 10 when the same is positioned on an operating surface, such as the bottom of a sump. For added stability, an optional pump base 32 may be used in combination with the support posts 30 to increase the cross-sectional support area. The pump base 32 may comprise an H-shaped plate, an I-shaped plate, a square plate, a square plate with extensions 34 and one or more cut-outs 36 (FIG. 1), and can include mounting bosses 38 for fastening the pump base 32 to a foundation, such as to a sump bottom, to a pond bottom, etc. In one exemplary embodiment, raised alignment segments 33 (FIG. 2) may be incorporated with the pump base 32 to interact with the support posts 30 and to align the support posts 30 relative to the pump base 32. For example, the support posts 30 can each comprise a recess 35 (FIG. 2) and the recess mounts over the raised alignment segment 33 of the pump base to delimit movement of the support post 30, and hence the pump assembly, relative to the pump base. An opening in each of the raised alignment segment 33 may be incorporated to then removeably fasten the pump base 32 to the pump assembly.

[0027] A carrying handle 40 comprising a grasping portion 42 flanked on two ends by attachment portions 44 may be used to facilitate moving or carrying the pump assembly 10. The carrying handle 40 may comprise a rust resistant material, such as a stainless steel material,

and the attachment portions 44 may be formed by bending the handle and coupling the attachment portions 44 to the receiving slots 46 formed in the inlet 22 and outlet 24 casings.

[0028] Although the pump housing 12 may be formed from a number of materials, in a preferred embodiment, the pump housing is molded from a thermoplastic material. In one exemplary embodiment, the inlet casing 22, the outlet casing 24, and the pump base 32 are molded from a glass-filled reinforced nylon. However, other thermoplastics (and combination with composites, fillers, or additives) having high strength and good stiffness properties are also acceptable. Such alternative materials include polysulfone (PSU), fiberglass reinforced ABS material, polyetherlimide (PEI), polyethersulfone (PES), and polyphenylsulfone (PPSU), just to name a few. Other possible candidates include polycarbonate (PC), polyphenylene, and thermoplastic polyurethane (TPU).

[0029] Turning now to FIG. 2, a semi-schematic cross-sectional side view of the pump assembly 10 of FIG. 1 is shown. The pump assembly 10 comprises a pump component 48 coupled to a driver component 50 and both components are positioned in an interior cavity 52 of the housing 12. In one exemplary embodiment, the pump component 48 comprises an impeller 54 mounted directly to a motor shaft 56 of the driver component 50. The driver component 50 comprises a standard single phase two pole AC motor, which includes standard motor components such as a rotor 58, a stator 60, an inboard bearing 62, an outboard bearing 64, a capacitor 66, and a motor casing 68. Other appropriately rated electrical motors may also be used without deviating from the spirit and scope of the present invention, including 110 volt and 220 volt motors.

[0030] In the present embodiment, the motor casing 68 comprises a front motor casing half 70 joined along a parting line 72 to a back motor casing half 74. The front and back motor casing halves 70, 74 are removeably secured along the parting line 72 by the outboard bearing 64 mating with the motor shaft 56 and the bearing race 76 of the rear motor casing half in an interference fit and by the inboard bearing 62 mating with the motor shaft 56 and the bearing race 76 of the front motor casing half 70 in an interference fit. Alternatively or in addition thereto, fasteners or conventional attachment means may be used to removeably secure the motor casing halves together. The attachment may be enhanced by the use of a mechanical seal 78, which is conventional in the art and comprises a primary sealing surface having a

rotating face and a stationary face. The mechanical seal 78 may also include secondary stationary seals such as an O-ring and/or packing material.

[0031] A motor housing flange 80 is incorporated on each motor casing half 70, 74. In one exemplary embodiment, the housing flange 80 of one motor casing half is abutted against the housing flange 80 of the other motor casing half at the parting line 72. As further discussed below, the flange 80 on the front motor casing half 70 may be used as a seat for a gasket or an O-ring 82, which, in one embodiment, is used to isolate the electrical connections and the capacitor 66 in the back of the motor from the pumped fluids. In an alternative embodiment, the motor casing 68 may incorporate a groove at the flange 80 for receiving the O-ring 82.

[0032] A motor electrical cover 84 comprising an open end 86 and a closed end 90 comprising a power terminal nozzle 92 may be incorporated to encase at least a portion of the driver component 50. In one exemplary embodiment, the motor electrical cover 84 is configured to slide over the motor 50 on the motor end comprising the capacitor 66 and over the pair of mating flanges 80 at the motor parting line 72. A cover flange 85 comprising a plurality of bosses or receptacles 100 located at the open end 86 of the electrical cover 84 is configured to mate with a mounting gland 94, which comprises a ring having a raised face 96 and extending bolt holes 98 along a bolt pattern (two shown). The mating between the cover flange 85 and the gland 94 facilitates compression on the O-ring 82 on the motor flanges 80 to then seal the electrical components at the back of the motor. At least some of the extending bolt holes 98 on the mounting gland 94 correspond with the bosses or receptacles 100 of the cover flange 85. Fasteners, screws, or combination bolts and nuts may be used with the gland 94 and cover flange 85 to impart a compressive force to the O-ring 82. Once the mounting gland 94 is in placed and properly secured to the cover flange 85, the open end 86 of the motor electrical cover 84 is sealed and the power connection cavity 88 at the back of the motor is isolated.

[0033] The power terminal nozzle 92 of the motor electrical cover 84 is configured to receive a power cord 102, which is fastened to the terminal nozzle 92 via a conventional water-tight terminal fitting 104. The various power cord lead lines 106 then connect to the terminal lines 108 of the stator 60 and the capacitor 66 (not shown). The power terminal nozzle 92 and the power cord 102 extend through a power cord opening 110 located in the rear pump housing casing 24. A seal between the power cord opening 110 and the power terminal nozzle 92 may be accomplished by compressing a gasket or an O-ring 112 at the interface therebetween.

[0034] An optional test pressure nozzle 114 may be incorporated at or near the enclosed end 90 of the motor electrical cover 84. The test pressure nozzle 114 may be used as an access port for pressurizing the power connection cavity 88, the interior of the motor, and the power cord termination with a pressure source, such as air pressure or other suitable gasses. For example, once the mounting gland 94 is assembled to the cover flange 85 and the O-ring 82 is compressed, the test pressure nozzle 14 may be used to pressurize the cavity 88, the motor, and the power cord termination to verify the seal. Once the test is completed, a plug 116, such as a bolt, a solid nipple, or alternatively a cap, may be used to seal the test pressure nozzle 114.

[0035] As previously discussed, the impeller 54 mounts directly onto the motor shaft 56. The impeller 54, which is a closed impeller but may alternatively be an open face impeller, comprises a front impeller shroud or face 118, a rear impeller shroud 120, and an opening 122 adapted to receive a portion of the motor shaft 56. A nut 124 may then be used to removeably secure the impeller 54 onto the motor shaft 56. A lock washer and other conventional fittings for securing a first component to a second component may also be used.

[0036] During use, the impeller 54 is rotated by the motor 50, which then creates a suction at the inlet nozzle 14. In one exemplary embodiment, the pump assembly is capable of both suction lift operation and suction head operation such that it can operate in either a sump service or an open-air service. When fluids flow through the impeller eye 126 and out the impeller periphery 128, the rotational energy of the fluids convert into pressure in the volute 130 section of the housing casing 22. The higher pressure fluids then flow to a lower pressure region, which is the outlet nozzle 16 at the rear housing casing 24. The fluids flow F across at least a portion of the motor casing 68. This flow arrangement over the motor casing allows the fluids F to cool the motor as they travel between the inlet nozzle and the outlet nozzle.

[0037] In one exemplary embodiment, the motor casing halves 70, 74 are fabricated from a rust resistant material, such as different grades of stainless steel, including 304 S.S. Alternatively only the front motor casing half 70 is made of a rust resistant material as the rear motor casing half 74 may be isolated from the fluids F via the motor electrical cover 84. In the embodiment shown, the impeller 54 and the motor electrical cover 84 may also be made from the same material as the pump housing 12 or alternatively from a different thermoplastic (with or without fillers or additives), one that exhibits strong toughness and strength characteristics.

[0038] Referring now to FIG. 3, a cross-sectional side view of the front inlet housing casing 22 is shown. Generally speaking, the front housing casing 22 has a partial non-symmetrical cone contour with a widest dimension near the open end 130. However, a generally rectangular casing, a square casing, or other non-circular casings may also be incorporated. At the upper portion 131 of the front housing casing 22, a bulge section 132 is molded along with a receiving slot 46 for receiving the attachment portion 44 of the carrying handle 40 (FIG. 1). The casing narrows from the open end 130 into a smaller dimensioned dome section with the inlet nozzle 14 having an opening 18 formed thereon. In one exemplary embodiment, as previously discussed, the inlet nozzle 14 is integrally formed to the casing with exterior male threads. Alternatively, the inlet nozzle 14 may comprise a male nipple in threaded communication with a female receptacle at the front housing casing 22. An integrally formed wear ring 135 is preferably formed at an interior tip of the nozzle 14 to receive the inlet shroud 118 of the impeller 54 (FIG. 1). Alternatively, the wear ring 135 can be an add-on component attached to the casing by fasteners, rivets, or the like.

[0039] At the lower end 133 of the front inlet housing casing 22, a generally flat planar section 134 is formed inwardly of the partial cone casing contour. The generally flat planar section 134 is configured to support a part of the driver component 50 (FIG. 2). Exteriorly, the generally flat planar section 134 defines a fastener channel 136 for receiving an attachment means 28 (FIG. 1). A flat flange section 138 at the end opening 130 adjacent the flat planar section 134 defines a bolt flange for the attachment means 28 to attach to. Although the generally flat planar section 134 is phrased "generally flat", a slight tapered from the opening towards the dome section at the inlet in the order of 1-20 degrees, a slight undulation in the surface of the planar section of a few to several thousandths, or even a slight curved surface are also permitted.

[0040] FIG. 4 is a semi-schematic end view of the front casing cover 22 of FIG. 3 taken along line F4-F4. An outer rim 140 and an inner rim 142 are incorporated with the casing cover 22. In one exemplary embodiment, the inner rim 142 comprises an end surface of an inner shell 144 formed by molding an inner layer originating from about the frontal cone section 146 (FIG. 3) to the end opening 130. The inner shell 144 may be attached to the outer shell 154 by integrally molded ribs 148 and by one or more flat flange sections 138.

[0041] In one exemplary embodiment, the inner shell 144 comprises two shell interfaces 150, 152. The first shell interface 150 comprises a smooth transition with the outer shell 154, and the second shell interface 152 comprises an angled transition 156, although the two transitions can also be the same and can comprise other curved transitions. Both the smooth transition portion 150 and the angled transition 156 extend from the opening 130 of the outer casing 154 to the frontal cone section 146 of the outer casing. The first and second shell interfaces 150, 152 define a flow channel 158 for the fluids F in passing from the inlet nozzle 14 to the outlet nozzle 16.

[0042] As readily apparent to a person of ordinary skill in the art, in flowing from between the inlet and the outlet nozzles, some of the fluids F may also travel outside the flow channel region 158 along the other portions of the interior surface 143 of the inner shell 144. Referring again to FIG. 2 in addition to FIG. 4, the fluids, in traveling from the inlet nozzle 14 to the outlet nozzle 16, generally travel inside the flow channel 158 and to some extent around at least some of the perimeter of the motor. Because of this flow configuration, the fluids travel around the top portion of the motor 50 and around at least some of the periphery of the motor to cool the motor. In one exemplary embodiment, when the motor is in position inside the casing cover, the peripheral flow is facilitated by providing a gap of about 1/8 inch to about 3/4 inch is provided between the inner shell 144 and the motor 50 with about 1/2 inch being more preferred. The gap between the upper surface 160 of the flow channel 158 and the motor 50 is about 1/2 inch to about 1-1/2 inches, with about 3/4 inch being more preferred.

[0043] Turning now to FIG. 5, a cross-sectional side view of the outlet housing casing 24 is shown. The outlet casing 24 comprises an outlet nozzle 16 having an opening 20 and a power terminal nozzle 92. Similar to the front housing casing 22, a generally flat planar section 134 is provided to support at least a portion of the driver component 50. Exteriorly, the flat planar section 134 defines a fastener channel 136 (FIG. 1).

[0044] FIG. 6 is a semi-schematic end view of the outlet housing casing 24 of FIG. 5 taken along line F6-F6. Similar to the inlet casing cover 22, the outlet casing cover 24 comprises an inner shell 144 and an outer shell 154. The inner shell 144 comprises two shell interfaces 150 with both shell interfaces having smooth transitions with the outer shell 154, although one smooth transition and one angled transition may be incorporated. The shell

interfaces 150 define a flow channel 158 that generally aligns with the flow channel 158 of the inlet casing cover 22.

[0045] One or more corresponding mating flange sections 138a may be provided to mate with the one or more flat flange sections 138 of the inlet casing cover 22. The mating flange sections 138a can embody the same structure as the flat flange sections 138 of the inlet casing cover 22 (FIG. 3) or alternatively comprise receiving female thread sections integrally molded with the casing (FIG. 5). In the integrally molded receiving female threads configuration of FIG. 5, mating nuts for the fasteners are eliminated as the receiving female thread sections 138a provide the mating function.

[0046] In addition to the one or more mating flange sections 138a, one or more bosses 162 and one or more side ribs 164 are provided to support the inner shell 144 and the outer shell 154. The bosses 162 also function as receiving mating portions for fasteners used to fasten the mounting gland 94 (FIG. 2). As previously discussed, in one embodiment, the mounting gland 94 is used to compress a gasket or an O-ring 82 positioned on the motor housing flange 80 to isolate the power connection cavity 88 from the fluids.

[0047] Also shown in FIG. 6 is the power terminal nozzle 92. Although the power terminal nozzle 92 is shown positioned directly below the outlet nozzle 16, it may be positioned elsewhere on the casing depending on the placement of the power cord opening 110 of the motor electrical cover 84 (FIG. 2).

[0048] FIG. 7 is a semi-schematic side view of the motor electrical casing cover 84. In one exemplary embodiment, the electrical casing cover 84 is generally cylindrical and comprises an indentation section 166 defining a lower flow channel 168. The indentation section 166 may be positioned along the same general orientation as the flow channel 158 defined by the transitions between the inner shell 144 and outer shell 154 of the rear casing cover 24. The upper and lower flow channels 158, 168 provide a flow forming section of the housing 12 so that pumped fluids narrow in contour prior to entering the outlet nozzle 16 to exit the pump casing. Although the flow F is said to flow over the motor via the flow channel, there may be flow dispersions around the motor as provided by the gaps between the motor and the inner casing, as discussed above.

[0049] The indentation section 166, which defines the lower flow channel 168, may be formed at about a 45 degree angle from the shell end 170. A curved profile 172 (FIG. 8)

along the surface of the indentation section 166 may be incorporated for the flow forming effect. In an alternative embodiment, the indentation section 166 may embody two or more distinct flow channels with a barrier or a separation section in between and may have a flat or a non-curved profile. Other changes may be incorporated to the indentation section 166 including changing the formed angle and all such changes are understood to fall within the spirit and scope of the present invention.

[0050] Turning now to FIG. 9, a closed face six-vane impeller 54 is shown. As previously discussed, the impeller 54 comprises a front shroud 118, a rear shroud 120, an impeller eye 126, and a mounting opening 122. A retaining sleeve or bushing 174 comprising a cylinder having a chamfered section may be co-molded with the mounting opening 122 in the rear shroud 120. The retaining sleeve 174 may comprise a metallic material such as stainless, brass, bronze, and other resistant metal and is adapted to fit over the motor shaft and be secured thereto. The particular impeller 54 profile may vary depending on the flow requirement, the operating rotational speed, the inlet conditions, the desired discharge or head pressure, and other parameters that are well known in the art. In the FIG. 2 embodiment shown, the pump has a flow capacity of about 4,000 gals/hr at one foot of lift, and a total differential head pressure of twenty eight feet.

[0051] Although the preferred embodiments of the in-line centrifugal pump have been described with some specificity, the description and drawings set forth herein are not intended to be delimiting, and persons of ordinary skill in the art will understand that various modifications may be made to the embodiments discussed herein without departing from the scope of the invention, and all such changes and modifications are intended to be encompassed within the appended claims. Various changes to the pump may be made including manufacturing the dimensions differently, using different materials, changing the interface between the various components to include contours, adding bolt patterns, changing the shape of the housing, changing the size of the housing, changing the capacity of the pump, changing the nozzle location, etc. For example, instead of using a closed face impeller, an open face impeller may be used and instead of providing one flow channel, provide more than one. Other changes may include adding colors to the casing finish, using dynamic packing instead of a mechanical seal, and incorporating connection fittings with the inlet and outlet nozzles. Accordingly, many

alterations and modifications may be made by those having ordinary skill in the art without deviating from the spirit and scope of the invention.